1.11 Waste Oil Combustion

1.11.1 General[1]

Waste oil includes used crankcase oils from automobiles and trucks, used industrial lubricating oils (such as metal working oils), and other used industrial oils (such as heat transfer fluids). When discarded, these oils become waste oils due to a breakdown of physical properties and contamination by the materials they come in contact with. The different types of waste oils may be burned as mixtures or as single fuels where supplies allow. Waste, or used, oil can be burned in a variety of combustion systems including industrial boilers; commercial/institutional boilers; space heaters; asphalt plants; cement and lime kilns; other types of dryers and calciners; and steel production blast furnaces. Boilers and space heaters consume the bulk of the waste oil burned. Space heaters are small combustion units (generally less than 250,000 British thermal units per hour [Btu/hr] input) that are common in automobile service stations and automotive repair shops where supplies of waste crankcase oil are available.

Boilers designed to burn No. 6 (residual) fuel oils or one of the distillate fuel oils can be used to burn waste oil, with or without modifications for optimizing combustion. As an alternative to boiler modification, the properties of waste oil can be modified by blending it with fuel oil, to the extent required to achieve a clean-burning fuel mixture.

1.11.2 Emissions[1]

The emissions from burning waste oils reflect the compositional variations of the waste oils. Potential pollutants include carbon monoxide (CO), sulfur oxides (SO_x), nitrogen oxides (NO_x), particulate matter (PM), particles less than 10 micrometers in size (PM-10), toxic metals, organic compounds, hydrogen chloride, and global warming gases (carbon dioxide [CO_2], methane [CH_4]).

Particulate Matter[1] -

Ash levels in waste oils are normally much higher than ash levels in either distillate oils or residual oils. Waste oils have substantially higher concentrations of most of the trace elements reported relative to those concentrations found in virgin fuel oils. Without air pollution controls, higher concentrations of ash and trace metals in the waste fuel translate to higher emission levels of PM and trace metals than is the case for virgin fuel oils.

Sulfur Oxides[1] -

Emissions of SO_x are a function of the sulfur content of the fuel. The sulfur content varies but some data suggest that uncontrolled SO_x emissions will increase when waste oil is substituted for a distillate oil but will decrease when residual oil is replaced.

Chlorinated Organics[1] -

Constituent chlorine in waste oils typically exceeds the concentration of chlorine in virgin distillate and residual oils. High levels of halogenated solvents are often found in waste oil as a result of inadvertent or deliberate addition of contaminant solvents to the waste oils. Many efficient combustors can destroy more than 99.99 percent of the chlorinated solvents present in the fuel. However, given the wide array of combustor types which burn waste oils, the presence of these compounds in the emission stream cannot be ruled out.

Other Organics[1] -

The flue gases from waste oil combustion often contain organic compounds other than chlorinated solvents. At ppmw levels, several hazardous organic compounds have been found in waste oils. Benzene, toluene, polychlorinated biphenyls (PCBs), and polychlorinated dibenzo-d-dioxins are a few of the hazardous compounds that have been detected in waste oil samples. Additionally, these hazardous compounds may be formed in the combustion process as products of incomplete combustion.

1.11.3 Controls[1]

Emissions can be controlled by the pretreatment of the waste oil to remove the pollutant precursors or with emission controls to remove the air pollutants. Reduction of emission levels is not the only purpose of pretreatment of the waste oil. Improvement in combustion efficiency and reduction of erosion and corrosion of the combustor internal surfaces are important considerations. The most common pretreatment scheme uses sedimentation followed by filtration. Water and large particles (greater than 10 microns in diameter) are removed without having much effect on sulfur, nitrogen, or chlorine contents. Other methods of pretreatment involve clay contacting; demetallization by acid, solvent, or chemical contacting; and thermal processing to remove residual water and light ends. These latter processes might be attractive as waste reduction schemes or to recycle the waste oil, but the added costs probably hinder their use as part of a combustion process.

Blending of waste oil with a virgin fuel oil is practiced frequently and has the same effect as some of the other pretreatment processes. However, for the purpose of developing emission factors, blending by itself was assumed to be in the uncontrolled category.

Waste oil serves as a substitute fuel for combustors designed to burn distillate or residual oils. Therefore, the emission controls are usually those in place when waste oil is first burned. For small boilers and space heaters, all of the sources having acceptable test data for determining emission factors were uncontrolled. For an asphalt plant, PM emissions, which included the dust from drying of the aggregate, were controlled with a fabric filter.

Emission factors and emission factor ratings for waste oil combustion are shown in Tables 1.11-1, 1.11-2, 1.11-3, 1.11-4, and 1.11-5. Emission factors have been determined for emissions from uncontrolled small boilers and space heaters combusting waste oil. These factors apply to both blended and unblended waste oil fuels when waste oil comprises the majority of the fuel combusted. If virgin oil comprises the majority of the fuel combusted, the emission factors presented in Section 1.3, Fuel Oil Combustion, should be used.

Evaporative emissions from waste oil used as a diluent in batch asphalt plants may be estimated using the procedures outlined in Section 4.5.

Tables in this section present emission factors on a volume basis ($lb/10^3 gal$). To convert to an energy basis (lb/MMBtu), divide by the heating value of the oil in units of $MMBtu/10^3 gal$, if known. If the heating value is not known, and the waste oil is blended with residual oil, divide by a heating value of 150 $MMBtu/10^3 gal$. If the waste oil is blended with distillate oil, divide by a heating value of 140 $MMBtu/10^3 gal$.

1.11.4 Updates Since the Fifth Edition

The Fifth Edition was released in January 1995. Revisions to this section since that date are summarized below. For further detail, consult the memoranda describing each supplement or the

background report for this section.

Supplement A, February 1996

- An earlier transcription error was corrected and the TOC emission factor was changed from 0.1 to 1.0 lb/1000 gal.

Supplement B, October 1996

- Math errors were corrected and factors for As, Be, Cd, Cr, Co, and speciated organics were changed.

- The CO_2 factors were revised based on a review of existing information.

Table 1.11-1. EMISSION FACTORS FOR PARTICULATE MATTER (PM), PARTICULATE MATTER LESS THAN 10 MICROMETERS (PM-10), AND LEAD (Pb) FROM WASTE OIL COMBUSTORS[a]

Source Category (SCC)	PM[b]		PM-10[c]		Pb[d]	
	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING
Small boilers (1-03-013-02)	64A[d]	C	51A	C	55L[f]	D
Space heaters Vaporizing burner (1-05-001-14, 1-05-002-14)	2.8A	D	ND	NA	0.41L	D
Atomizing burner (1-05-001-13, 1-05-002-13)	66A	D	57A	E	50L	D

[a] Units are lb of pollutant/10^3 gallons of blended waste oil burned. To convert from lb/10^3 gallons to kg/m^3, multiply by 0.12. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] References 2-5.

[c] Reference 1.

[d] References 4-6.

[e] A = weight % ash in fuel. Multiply numeric value by A to obtain emission factor. For example, if ash content is 5%, then A = 5.

[f] L = weight % lead in fuel. Multiply numeric value by L to obtain emission factor. For example, if lead content is 5%, then L = 5.

Table 1.11-2. EMISSION FACTORS FOR NITROGEN OXIDES (NO_x), SULFUR OXIDES (SO_x), AND CARBON MONOXIDE (CO) FROM WASTE OIL COMBUSTORS[a]

Source Category (SCC)	NO_x[b]		SO_x[b]		CO[c]	
	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING
Small boilers (1-03-013-02)	19	C	147S[d]	C	5	D
Space heaters Vaporizing burner (1-05-001-14, 1-05-002-14)	11	D	100S[d]	D	1.7	D
Atomizing burner (1-05-001-13, 1-05-002-13)	16	D	107S[d]	D	2.1	D

[a] Units are lb of pollutant/10^3 gallons of blended waste oil burned. To convert from $lb/10^3$ gallons to kg/m^3, multiply by 0.12. SCC = Source Classification Code.

[b] References 4, 7.

[c] References 2, 5.

[d] S = weight % sulfur in fuel. Multiply numeric value by S to obtain emission factor. For example, if sulfur content is 3.4%, then S = 3.4.

Table 1.11-3. EMISSION FACTORS FOR TOTAL ORGANIC COMPOUNDS (TOC), HYDROGEN CHLORIDE (HCl), AND CARBON DIOXIDE (CO_2) FROM WASTE OIL COMBUSTORS[a]

Source Category (SCC)	TOC[b]		HCl[b]		CO_2[c]	
	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING
Small boilers (1-03-013-02)	1.0	D	66Cl[d]	C	22,000	C
Space heaters Vaporizing burner (1-05-001-14, 1-05-002-14)	1.0	D	ND	NA	22,000	D
Atomizing burner (1-05-001-13, 1-05-002-13)	1.0	D	ND	NA	22,000	D

[a] Units are lb of pollutant/10^3 gallons of blended waste oil burned. To convert from $lb/10^3$ gallons to kg/m^3, multiply by 0.12. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Reference 1.

[c] References 2-4. Ranges from 18,000 to 25,000 lb of $CO_2/10^3$gal, depending on carbon content.

[d] Cl = weight % chlorine in fuel. Multiply numeric value by Cl to obtain emission factor. For example, if chlorine content is 3%, Cl = 3.

Table 1.11-4. EMISSION FACTORS FOR SPECIATED METALS FROM WASTE OIL COMBUSTORS[a]

EMISSION FACTOR RATING: D

Pollutant	Small Boilers Emission Factor ($lb/10^3$ gal)[b] (SCC 1-03-013-02)	Space Heaters: Vaporizing Burner Emission Factor ($lb/10^3$ gal)[c] (SCC 1-05-001-14, 1-05-002-14)	Space Heaters: Atomizing Burner Emission Factor ($lb/10^3$ gal)[c] (SCC 1-05-001-13, 1-05-002-13)
Antimony	BDL	3.4 E-04	4.5 E-03
Arsenic	1.1 E-01	2.5 E-03	6.0 E-02
Beryllium	BDL	BDL	1.8 E-03
Cadmium	9.3 E-03	1.5 E-04	1.2 E-02
Chromium	2.0 E-02	1.9 E-01	1.8 E-01
Cobalt	2.1 E-04	5.7 E-03	5.2 E-03
Manganese	6.8 E-02	2.2 E-03	5.0 E-02
Nickel	1.1 E-02	5.0 E-02	1.6 E-01
Selenium	BDL	BDL	BDL
Phosphorous	ND	3.6 E-02	ND

[a] Pollutants in this table represent metal species measured for waste oil combustors. Other metal species may also have been emitted but were either not measured or were present at concentrations below analytical detection limits. Units are lb of pollutant/10^3 gallons of waste oil burned. To convert from $lb/10^3$ gallons to kg/m^3, multiply by 0.12. BDL = below detection limit. SCC = Source Classification Code. ND = no data.

[b] Reference 4.

[c] References 4-5.

Table 1.11-5. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM WASTE OIL COMBUSTORS[a]

EMISSION FACTOR RATING: D

Pollutant	Space Heaters: Vaporizing Burner (SCC 1-05-001-14, 1-05-002-14) Emission Factor (lb/10^3 gal)	Space Heaters: Atomizing Burner (SCC 1-05-001-13, 1-05-002-13) Emission Factor (lb/10^3 gal)
Phenol	2.4 E-03	2.8 E-05
Dichlorobenzene	8.0 E-07	ND
Naphthalene	1.3 E-02	9.2 E-05
Phenanthrene/anthracene	1.1 E-02	1.0 E-04
Dibutylphthalate	ND	3.4 E-05
Butylbenzylphthalate	5.1 E-04	ND
Bis(2-ethylhexyl)phthalate	2.2 E-03	ND
Pyrene	7.1 E-03	8.3 E-06
Benz(a)anthracene/chrysene	4.0 E-03	ND
Benzo(a)pyrene	4.0 E-03	ND
Trichloroethylene	ND	ND

[a] Reference 4. Pollutants in this table represent organic species measured for waste oil combustors. Other organic species may also have been emitted but were either not measured or were present at concentrations below analytical detection limits. Units are lb of pollutant/10^3 gallons of waste oil burned. To convert from lb/10^3 gallons to kg/m^3, multiply by 0.12. SCC = Source Classification Code. ND = no data.

References For Section 1.11

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2. *Environmental Characterization Of Disposal Of Waste Oils In Small Combustors*, EPA-600/2-84-150, U. S. Environmental Protection Agency, Cincinnati, OH, September 1984.

3. *Used Oil Burned As A Fuel*, EPA-SW-892, U. S. Environmental Protection Agency, Washington, DC, August 1980.

4. *The Fate Of Hazardous And Nonhazardous Wastes In Used Oil Disposal And Recycling*, DOE/BC/10375-6, U. S. Department of Energy, Bartlesville, OK, October 1983.

5. "Comparisons of Air Pollutant Emissions from Vaporizing and Air Atomizing Waste Oil Heaters", *Journal Of The Air Pollution Control Association*, 33(7), July 1983.

6. "Waste Oil Combustion: An Environmental Case Study", Presented at the 75th Annual Meeting of the Air Pollution Control Association, June 1982.

7. *Chemical Analysis Of Waste Crankcase Oil Combustion Samples*, EPA600/7-83-026, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 1983.